WATERSHED WORK PLAN

UPPER MILL CREEK WATERSHED

Butler and Hamilton Counties, Ohio

March 1968

SUMMARY OF PLAN

This plan is for watershed protection, flood prevention, and waterbased recreational facilities in the Upper Mill Creek Watershed. The drainage area is 30,590 acres (47.8 square mile) with 22,640 acres in Butler County and 7,950 acres in Hamilton County. The watershed, located about eight miles southeast of the industrial city of Hamilton, drains a agricultural area of southeastern Butler County, and extends about three miles into the predominantly industrialized Mill Creek Valley of Hamilton County. The watershed is experiencing rapid industrialization, and the changed land use trend from agricultural to urban is expected to be completed within 20 to 25 years. Existing land use is 45 percent cropland, 14 percent pasture, 10 percent woodland and 31 percent other. Mill Creek below the project area flows southward about 18 miles through a highly developed industrial complex in Hamilton County, where it outlets into the Ohio River at Cincinnati.

The Sponsoring Local Organizations of this work plan are the Southern Butler County Conservancy District, the Butler County Commissioners, the Butler Soil and Water Conservation District and the Hamilton Soil and Water Conservation District.

Floods, causing extensive damage to agricultural lands, industries and transportation facilities, occur one or more times

yearly, with recent major floods occurring in 1959, 1963 and 1964. The serious flood problem that exists with inadequate agricultural levees will continue to increase with industrial development as individual industries in the flood plain strive to protect themselves by levees or by building on fill. Both methods usurp floodwater storage, causing higher flood stages on the remaining agricultural lands, transportation facilities and the other industries. With the impending industrial development of remaining open areas in the valley, the sponsors forsee the need for starting now with a coordinated plan for watershed protection, flood control, future water supply, low flow augumentation and recreational facilities.

This plan contains the results of a comprehensive study of water resource related problems of the watershed. Land treatment to reduce erosion, sedimentation and runoff, four floodwater detention structures, one multiple purpose structure and 10.4 miles of major channel improvements for flood control are the works of improvement planned for installation under Public Law 566. A metropolitan recreation facility around a 50 acre lake formed by the multiple purpose dam is included. The works of improvement will provide a 100-year level of protection to 3,490 acres in the Upper Mill Creek Valley.

With inadequate storage available at the structure sites for purposes other than flood prevention, the sponsors will look toward the State's Southwestern Ohio Water Management Plan for guidance on future water supply and quality.

With the urgent need for the sponsors to obtain land rights for the structures in the upland areas where the urbanization pressure is the strongest, the installation period for the works of improvement is estimated to be five years; however, the main stem channel improvement is dependent on an outlet being provided by the plans being studied by the U. S. Army Corps of Engineers as part of the Southwestern Ohio Plan. They are reviewing the Official Plan for the Millcreek Valley Conservancy District, which recommends 17.5 miles of channel improvement through Hamilton County.

Land treatment installation costs have been estimated at $19,592 for technical assistance chargeable to PL-566, while charges to other funds will amount to $90,322. The total installation cost of project structural measures is $5,832,210. The PL-566 share is $4,118,280, leaving a balance of $1,713,930 to be borne by sources other than PL-566.

The Southern Butler County Conservancy District and the Millcreek Valley Conservancy District have authority, including the rights of taxation and eminant domain, to properly and legally execute this work plan under Ohio laws. Operation and maintenance of land treatment measures will be by landowners and operators, while operation and maintenance of the structural works of improvement will be the responsibility of the Conservancy Districts involved.

The estimated average annual cost of operation and maintenance of the structural works of improvement is $22,110, which includes $12,000 for the planned recreational facilities.

The total estimated average annual benefits from the project amount to $1,665,950, and the estimated annual costs of installing, operating and maintaining the works of improvement are $219,710, yielding a benefit-to-cost ratio of 7.6 to 1.

DESCRIPTION OF THE WATERSHED

Physical Data

General - The Upper Mill Creek Watershed is an irregularly shaped area of 30 590 acres or 47.8 square miles, of which 22,640 Acres (74%) lies within southeast Butler County& 7 950 Acres) (26%) within northeast Hamilton County. The watershed includes the area that drains into Mill Creek above its junction with Sharon Creek. The watershed is approximately 10 miles north of Cincinnati, Ohio.

Mill Creek originates about 3 miles southeast of the city of Hamilton and flows in the general direction of southeast to the county line; just below which it is joined by the East Fork of Mill Creek, the main tributary. From this point it flows south, then southwest through Cincinnati to the Ohio River.

A portion of the abandoned Miami & Erie Canal that connected Hamilton and Cincinnati parallels Mill Creek.

Topographically, the watershed is one of low to moderate rolling hills surrounding a wide flat valley through which Mill Creek flows. The maximum relief in the watershed is 422 feet. Mill Creek has developed a dendritic (tree like) drainage pattern. Within the watershed it has a gradient of 4 to 5 feet per mile. Below Sharon Creek the gradient increases to about 8 feet per mile. This low gradient in the upper area produces a drainage problem in the bottomland areas. The Mill Creek Valley in the watershed averages over 1 mile in width and covers about 7,000 acres. There are 2 interstate highways, 6 state roads, and numerous county roads traversing the watershed. Three railroads numerous pipelines, and electric transmission lines cross the area. Principal towns are Princetown, Tylersville

Westchester, Port Union, Rialto, Crescentville, Springdale and Glendale.

Geology and Soils - The watershed lies within the Till Plains region of Ohio. Illinoian and later Wisconsin glaciers of Pleistocene time have modified the preglacial landforms and drainage. Mill Creek flows through a tributary valley of the old Teays River, the Norwood Stream, now covered by 200 feet of sands, gravels, and clays deposited by the glaciers. Wisconsin till (glacially deposited material) in the surrounding hills is much thinner and probably averages 5 feet. Thicker till deposits such as drumlins and end moraines are found locally. Stream-laid deposits from glacial outwash are rare. Sands and gravels have been quarried east of West Chester.

Underlying bedrock consists of horizontally bedded calcareous shales and thin-bedded limestones of the Eden, Marysville, and Richmond Formations located on the axis of the Cincinnati arch. All are Ordovician in age. Bedrock is exposed in stream beds of tributaries to Mill Creek, and in roadcuts.

The major soils are Russell, Wynn, Xenia, Fincastle, Fairmont, Corwin and Genessee. All are within the High Lime Wisconsin Till Soil Region.

Russell, Xenia, Wynn, and Fincastle soils have formed from thin loess (wind-blown) deposits over highly calcareous glacial till. They are all silty and well drained, except for Fincastle which is poorly drained.

Fairmont soils are well drained soils formed on top of thin bedded limestones and calcareous shales that form the bedrock of the area.

Genessee soils are well drained, that form in alluvium (stream deposits) from highly calcareous till on nearly level first bottoms. Corwin soils are well drained, and formed on the calcareous till itself.

Water Supplies - Water supplies in the northern portion of the watershed are presently obtained from ground water, rather than from surface water of Mill Creek or its tributaries.

Two pre-glacial streams, the Norwood and Hamilton streams, join in the vacinity of the city of Hamilton. Wells drilled into these gravel-filled buried valleys supply water for the city of Hamilton. Water from this source is fed through waterlines to the West Chester-Pisgah area. Waterlines from Hamilton to the Princeton area which will supply the remainder of the northern portion of the watershed. Some businesses, at present obtain water supplies from wells drilled into the aquifer along Mill Creek within Butler County. Wells drilled within Mill Creek Valley at Cresentville yield 600 gallons per minute.

Ground water supplies in the upland (not underlain by buried valleys) is scarce. Bedrock is tight and in general provides inadequate supplies of water. Wells drilled by individual landowners here give yields at less than 5 gallons per minute on the average.

Much of the water supply of the southern part of the watershed is furnished by the Cincinnati water system. Pipelines from Cincinnati extend north up to Port Union, supplying that town, and also the industrial complex within the Mill Creek Valley with water. Future water for the industrial complex is obtained from ground water within the Miami River Valley south of Hamilton and piped overland to the

consumers. The resultant reduction in local pumping and discharge of used water into the Mill Creek Valley aquifer, has raised the water table.

Adequate ground water is available for irrigation of specialized crops should their production become prevalent with project protection.

Forests - There are 3,050 acres of forest land. The hydrologic condition of the forest land ranges from generally poor, to fair or average in some areas. As the result of a period of relative non-use, much of the forest land is now recovering from an extended period of miss-use. The hydrologic condition of existing areas is expected to improve the current level of protection.

Climate - The climate is Humid Continental. Mean annual rainfall is 39 inches, and the greatest amount of rainfall occurs in April and the summer months. The mean annual temperature is 54°F., with a low of 33°F. in January and high of 76°F. in July. There is a 10% chance of killing frost between May 16-26 in the spring and between September 19-28 in the fall. Prevailing winds are from the west.

Economic Data:

The watershed predominantly agricultural in the past, remains presently 59 percent in agricultural production. However, the Cincinnati industrial-urban complex (population approximately 500,000) has expanded well into the lower portions of the watershed. Also, the Hamilton-Fairfield industrial-urban complex (population 83 000) has moved into the upper end of the main Mill Creek Valley. A survey of the present rate of development on both ends of the watershed indicates that the industrial development of the flood plain will be complete in 20 to 25 years. It is ex-

pected that residentail development will continue at a similar pace, and will involve much of the upland areas that are less desirable for industrial development. Three railroads pass through the watershed and three Interstate Highways pass through or near the area. Current land values in the main valley range generally from $2,000 to $5,000 per acre. A few selected sales have been much higher. On the upland areas the values range between $500 and $1,000 per acre. These values represent prices that have been paid in recent real estate transactions in the area. All the land is privately owned except for one U. S. Reservation of about 550 acres.

Farm Data - There are an estimated 222 farms in the watershed with an average of 131 acres. General type farming prevails, with major crops being corn, grain, and Hay, along with some vegetables and nursery stock. The sale of livestock and livestock products furnishes the primary source of agricultural income. Many of these farms have "For Sale" signs out front, indicating they are available for industrial development. It is estimated that 50 percent of the farm operations are part-time with one or more family members employed in the nearby industries.

Soil and water conservation districts have active programs within this watershed. Of the 65 district cooperators it is estimated that 88 percent have basic conservation plans on all their land. The plans cover an average 134 acres each a high percentage of planned land treatment measures have been applied to the land. Typical crop yields to an acre are: Corn - 70 bushels; Wheat - 30 bushels, and hay - 2 tons. Of the cropland in the area about 50 percent is used for corn, 16 percent for grain, 4 percent soybeans, and 30 percent hay.

Population Trends and Future Growth - Based on 1964 Bureau of Census data, the population of the watershed is estimated at 20,730. This includes the 9,573 people who live in the watershed s largest towns, Springdale and Glendale. It also includes 7½ percent of the rural population of Butler County and 3 percent of the similar portion of Hamilton County. The above percentages representthe portion of each county that comprises the watershed. Farm operator households in the watershed contain 410 persons on the same basis. The rate of population increase in the area has been about 1½ percent a year recently. It is expected that the rate of growth may increase in the watershed due to the open area made available once flooding protection is provided. Direct access to several Interstate Highways and railroads along with adequate water supplies affords this area great urban development potential. Recent trends in agriculture are toward fewer farms with larger farm units; with more of the part-time farmers discontinuing operations and making their field available to nearby full time operators. The project proposal which includes recreation can be attractive for accelerated urban developments.

Forest Data - Approximately 10 percent (3,050 acres) of the watershed is in forest cover. The majority of the forest land is located in the northeastern third of the watershed. This is the slightly rolling upland portion of the area. Hardwood stands, composed mainly of the oak-hickory type with some areas in sugar maple-beech type, occupy all the forest land. Associated species are white ash, hickory, white, red, black and scarlet oak, sugar maple hackberry elm, beech, black walnut honey locust, and black cherry. Residential and industrial development is expected to reduce the present forest acreage. There are good markets for veneer and

quality sawlogs. The lower quality timber can be sold for pallet and dunnage stock. Adequate forest fire protection is provided by the local Township fire departments. Going Federal-State Cooperative Forestry Programs include: Cooperative Forest Management (CFM), Cooperative Forestation (C-M), and Cooperative Forest Insect and Disease Control.

Fish and Wildlife - The fishery resource of Mill Creek itself is virtually nonexistent due primarily to the small stream size, and to past dredging and straightening operations. Several privately owned pay fishing lakes are found in the watershed.

Wildlife cover capable of supporting significant game populations is lacking both quality and quantity in the watershed. Principal game species are cottontail rabbit and bobwhite quail, although squirrels are found in limited numbers.

The present land-use trend indicates that industrial development of the flood plain and suburban development of the uplands will be completed soon. This, plus the proposed channel improvement part of the project will cause only minor losses to wildlife habitat and not greatly effect its potential.

WATERSHED PROBLEMS

Land Treatment:

The advancing urbanization of this watershed will require many adjustments in the land treatment program. However, erosion of uplands and frequent flooding of bottomlands are dominant problems. Additional land treatment will help to control runoff reduce soil loss, and increase infiltration. A considerable portion of the bottoms, as well as the upland, is now in cropland and pasture. Much of this land is in

need of further conservation treatment. Overgrazing and a lack of good pasture management is contributing to runoff and soil loss.

Although flooding is the main problem on the bottom land natural surface and internal drainage are less perfect in scattered locations. Adequate drainage outlets have been provided by improvements made to existing channels.

The present agricultural areas of the flood plain could be more productively used if the flood hazard were reduced.

Better cover conditions could now be obtained in the upland by converting the steeper cropland areas to hayland, pasture, or woodland.

Although the soils are responsive to treatment the application of lime and fertilizer is often minimized in the flood plain because of the flooding hazard. Some adjustments are needed to align cropping patterns with land capabilities.

Floodwater Damage:

A serious floodwater problem was defined on 2,850 acres or 9.3 percent of the Mill Creek Watershed. About 66 percent of the flooded area is in Butler County and the remainder in Hamilton County.

Lateral channels north and east of Mill Creek contribute flood flows directly into the main stem. The tributaries south and west of Mill Creek have been modified by the abandoned Miami and Erie Canal and the Penn Central Railroad. These tributaries which used to pass over or under the old canal now cut through or flow in part of the canal. They are usually dyked across the flood plain and pass under the railroad before emptying into Mill Creek. Individual property owners have constructed levees along the main stem and tributaries in order to con-

tain the more frequent floods. Both flap gates and pumps are being used to control drainage behind the levees. The present inadequate levee system is now increasing the duration of some floods and increase the floodwater drainage.

Adding to the problem is a limited amount of flood flow that enters the watershed from the city of Hamilton's Industrial Park area (Sec. 22 Fairfield Twp.) via the old canal system. This area normally drains out through the city of Fairfield into the Great Miami River. Despite the large amount of natural storage in this area, water backs over the divide into Mill Creek.

Most floods in the watershed have occurred in late winter, spring, and early summer. A stream gage is located downstream at Reading, Ohio. Records show that major floods occurred in March 1945, April 1940, January 1959, March 1963, and March 1964. The January 1959 flood caused damages exceeding $1,000 000 within the watershed. If the same 1959 rainfall occurred in January 1968, it would have resulted in flood damage estimated at $400,000. This decrease is due in part to the effect of raised and improved levees around some of the industries which were severely damaged in 1959. However, with continued expansion of urban developments in the flood plain area, a 1959 flood occurring in the future will easily top the one million dollars damage figure.

With the anticipated urban development in the watershed, the 100-year storm is expected to inundate an additional 640 acres or a total of 3,490 acres, 11.4% of the watershed. Other synethic storm frequencies and conditions are shown in the following table:

Flood Frequency and Condition	Percent Chance of occurrence in any one year	Acres Inundated	Percent of 100-year Acres Inundated
With Existing Watershed Conditions			
100-year	1%	2,850	100%
25-year	4%	2,435	85%
10-year	10%	2,190	77%
5-year	20%	1,950	68%
2-year	50%	1,530	54%
With Projected Urban Growth			
100-year	1%	3,490	100%
24-year	4%	2,955	85%
10-year	10%	2,600	74%
5-year	20%	2,315	66%
2-year	50%	1,820	52%

Average annual damage to crops and pasture from overland flooding is estimated to be $5,926. This damage is caused by frequent growing season floods. Five of fifteen floods that occurred from July, 1958 to March, 1964 were during the growing season. At least one flood occurred every year from 1939 thru 1964. Floods of small magnitude accumulatively create the greatest agricultural damage.

Flood plain farmers are experiencing one to three floods a year. In addition to direct crop and pasture damage, the frequent floods prevent farmers from operating their lands efficiently. Replanting or the delayed planting of crops are common.

Other agricultural damages to farmsteads, levees from roads and bridges fences livestock losses, and cost of debris removal is esti-

mated at $3,187 annually. Flood damage to scattered non-farm residences and to a trailer court is also included.

It is anticipated that all agricultural areas will be taken over by industries in the next 20 to 25 years. Agricultural damages were evaluated accordingly and amortized over the estimated 100-year life of the project.

Transportation floodwater damages to highways, railroads and bridges were estimated at $6 245 annually.

An estimated 8 miles of highways are subject to damage by flooding and washouts. The average annual floodwater damage to roads and bridges is estimated to be $1,173.

Railroad damages occur during the larger floods. An estimated 6.5 miles of railroad tracks are affected. Ballast washout and buckled rails result in disrupted traffic, large repair costs and loss of revenue. Saturation of the road bed causes pumping and leads to deterioration of the ties and loosening of the rails. Average annual damages to railroads by floodwater were estimated at $5,072.

Urban type damages occur in the flood plain. Rapid industrial development in the watershed has been made and is expected to continue. Levees have been built by property owners in attempts to minimize floodwater damages. Such levees have been haphazardly built from time to time and may induce flooding on other properties. Major flood damages in the watershed are caused by medium and high flood stages.

Due to the rapid industrial growth in the flood plain, damages were evaluated for present and future developments. Studies of the rate of industrial growth indicate that the flood plain will be com-

pletely industrialized in the next 20 to 25 years. Projected damages were appropriately lagged. Total estimated average annual urban damages are $1,302 322. Existing average annual damages to the 19 industrial properties now located on the flood plain are estimated to be $200,520. Anticipated expansion of the existing properties are included in the projected damages.

Erosion Damage:

Cultivated areas within the watershed have only slight to moderate sheet erosion. Much of the idle land is covered with small brush and susceptible to only slight sheet erosion. Gullying is infrequent and not a serious problem.

Suburban construction has been on the increase in past years, and is expected to continue in this fasion for the future. Erosion from this source should occur for a few years at each construction site.

Road bank erosion is not a serious problem. Erosion of soil and rock in the uplands along roads is slight and that in Mill Creek Valley itself, is negligible.

Normal channel bank erosion occurs along streams within the watershed. Soil eroded from streambanks is moved short distances downstream and deposited. Vegetation along much of the stream channel holds this type of erosion to a minimum.

No scouring of the flood plain by stream overwash was found.

Sediment Damage:

Most sediment deposited in fields during flooding consists of fine particles and is not considered harmful to crop growing. Deposits of sand and coarser materials are minor and would not be significantly detrimental.

Sediment in the stream channels consists principally of silt and scattered gravel. Most fine particles are carried downstream during flood times, some passing out of the watershed.

No swamping has been caused by channel deposition.

Problems Relating to Water Management:

Drainage - Considerable local effort has been spent to provide the needed drainage systems, including outlets. These efforts will be continued as a part of the overall land treatment program. The need for supplemental drainage to agricultural land is expected to diminish as urbanization engulfs the area.

Recreation - There are few recreational developments in this part of Ohio. More than one million people live within a half-hour drive of the watershed. Four fishing lakes with a combined surface area of about 348 acres are available to the public. The nearest state lakes Houston Woods and Stonelick Lake are both about 30 miles in opposite directions from the center of the watershed. The Hamilton County Park District however, control the Winton Woods and Sharon Woods Lakes which are both located just south of the watershed. Water based recreation is still sorely needed in the area. Local sponsors recognize the need and plan to incorporate storage of recreation water in Structure No. 2 along with basic facilities to exploit this resource.

Fish and Wildlife - A shortage of good quality cover along with heavy hunting pressure are problems throughout the watershed. Only a few people can satisfy the desire for a good day of fishing due to a lack of water properly stocked.

Municipal and Industrial Water - Present quantities of water are adequate to meet existing needs except in the northern upland portion of the watershed, as previously mentioned.

Future supplies of water are expected to come from the present sources, but in greater quantity to meet increasing needs. The northern portion of the watershed will probably be served almost completely by the city of Hamilton's pipelines. The southern portion will be supplied by the Cincinnati System. Local municipalities or industries within the Mill Creek Valley will have either of these supplies, or can drill to the aquifer beneath the valley which has large supplies.

PROJECTS OF OTHER AGENCIES

The Ohio Water Commission, Department of Natural Resources, has undertaken a State water plan for the development of the water resources of Ohio. The State has been divided into five major regions for this study. Southwestern Ohio which includes the Miami, Little Miami and Mill Creek Basins is the region of current interest. The State of Ohio requested Congress to make this investigation. The Department of the Army, Louisville District, Corps of Engineers, has been assigned by Congress the overall leadership for the cooperative study involving Federal State, and local agencies and private enterprises. The study will consider all phases of the region's water and related land resource needs and potentials, including flood control, water quality control, water supply, recreation, fish and wildlife conservation and enhancement. The Southwest Ohio Plan is estimated to take four years to complete through Fiscal Year 1972.

Within the area covered by the Southwestern Ohio Plan lies the Water Conservation Sub-district of the Miami Conservancy District. This Sub-district extended its boundaries to include the Mill Creek Valley in Butler County as of June 1967. It is to provide for the co-ordination and optimum development and use of the water supplies of the buried valleys within this region of the Great Miami River. The Sub-District is also cooperating with the State in the Southwestern Ohio Plan which will consider the transfer of water from one river basin to another to meet future water supply needs and water quality management.

The Mill Creek Valley Conservancy District, organized in Hamilton County, authorized the engineering consultant firm of Vogt Ivers and Associates to develop a comprehensive plan for flood alleviation for the lower Mill Creek Valley. This plan which consists of 17.5 miles of channel improvement at the cost of 15 253 000 dollars, was adopted as the District's official plan in 1965. The channel work, which would provide a 50-year level of protection was set up to be done in eight stages starting at the Barrier Dam near the Ohio River, upstream to the Hamilton-Butler County Line. The last stage being a transition back to the existing channel.

In order for the Conservancy District to qualify for federal cost sharing for flood prevention on its Official Plan the Conservancy District asked the Corps of Engineers, Louisville District, to make an economic feasibility study of their plan. The Mill Creek Interim Report scheduled for fiscal year 1969, will then recommend Congressional authorization of construction funds. This report will be an integral part of the Southwestern Ohio Water Resource Plan.

The channel improvements proposed in this work plan depend on the work in the lower Mill Creek Valley for an adequate outlet. The floodwater retarding structures which help keep the channel improvement within practical size limitations are independent. This work plan, which will be part of the overall coordinated Southwestern Ohio Plan for Mill Creek, is needed for the Southern Butler County Conservancy District to obtain land rights in the headwater areas where the urbanization pressure is the strongest.

The Corps of Engineers, as part of their Mill Creek Interim Report, will study the best location for the transition between the proposed channel improvement plans. Previous reports by the Corps of Engineers in 1938, 1942, 1945, and 1952 have resulted in the construction of the Barrier Dam with pumping station for protection against Ohio River backwater in the Mill Creek Valley and the West Fork of Mill Creek Flood Control Reservoir located about two miles southwest of Springdale in Hamilton County.

BASIS FOR PROJECT FORMULATION

Sponsors of the Upper Mill Creek Watershed application requested that a comprehensive plan be developed to bring under control the water and soil resources of the Mill Creek Valley for the people living within this Butler County and the northern part of Hamilton County area. Within this overall objective the sponsors stressed the following sub-objectives: to control or reduce floodwater and sediment damage; to promote good land use by reducing rapid runoff and soil erosion; to study water storage potential for water supply, low flow augmentation and recreational possibilities.

In order to accomplish the project objectives it was agreed by the sponsors that a combination of the following measures should be included in the plan:

1. Land treatment measures, with accelerated technical assistance, for the establishment of soil erosion and water control measures, good agronomic practices and wildlife habitat development and preservation.
2. Floodwater retarding structures to store floodwater after periods of high runoff, and release it slowly over a period of time.
3. Water storage for water based recreation at one of the floodwater retarding structures.
4. Improved channels to increase floodwater carrying capacity, to control channel erosion and provide the desired level of flood protection.

Under the authority of Public Law 566, areas of industrial and commercial development require a minimum level of protection from flood flows up to the 100-year recurrence interval (1% chance of occurrence) or the largest flood of record, which ever is greater. The largest known flood in the watershed is generally considered to have occurred in 1913. A lessor level of protection would suffice for the present agricultural floodplain use and still give a substantial reduction of the Non-Agricultural developments. The sponsors and the Soil Conservation Service, however, agreed upon the higher, 100-year level of protection after studying all available data on the projected urban growth in the watershed.

Existing land treatment efforts will be directed towards improving lands which presently need treatment while being used for agricultural purposes. Priority will be given to those areas which need treatment, located above flood water retarding structures.

Future land treatment will be directed towards urban needs. Urban residential developments are now spreading into the upland areas. Although soil erosion is not a serious problem in the watershed, technical assistance will be directed towards developers and builders, as needed, to prevent, where possible, the occurrence of any localized erosion problems.

Six potential floodwater retarding sites were originally selected to control as much drainage area as possible above the main damage areas. Careful analysis was made of the engineering, geologic hydrologic and economic phases of each site. After due consideration by the sponsors of all the aspects involved, including installation costs and effects on reducing flood flows, five sites controlling 32 percent of the watershed were selected. Site No. 3 on the main tributary south of Port Union was deleted from the plan at the request of the sponsors. This request was made when a contract was let to construct a sanitary sewer system which will outlet into Mill Creek. A trunk line will run up the tributary through the site in order to serve a new commercial and industrial development. The relocation or modification of this sewer line would be a major local cost. This site had limited effect under existing flow conditions because it is located south of both the old canal and railroad. In the future, with channelization and an adequate outlet, it would contribute directly to flood peaks. In order to

achieve the level of flood protection desired by the sponsors, the floodwater retarding effect of the remaining five structures must be supplemented by major channel improvements.

The channels were found to be of adequate depth and capacity for normal surface and internal drainage of the agricultural lands except for some low areas which are being pump drained. The channel improvements will have some adverse affect on the present, limited, wildlife resource. The land treatment program, as well as the permanent pools behind the structure sites, will help mitigate this loss.

The decision on where to end the downstream channel improvements was given considerable attention. In order to allow maximum flexibility, this work plan carries the improvement without levees to the end of the watershed application at the junction with Sharon Creek. This gives the Corps of Engineers an opportunity to study other transition areas as a part of the Southwestern Ohio Plan.

To help meet the recreation demand in Butler County, the sponsors examined the potential of all the floodwater retarding sites. This resulted in a request that additional storage for recreation needs be incorporated into the design at Site No. 2. The Butler County Park Board furnished assistance as to the type and extent of facilities they thought desirable for a small 50 acre lake. This limited development is patterned after the Sharon Woods Metropolitan Park in Hamilton County.

The need for future water supply and low flow augmentation storage was considered. It was evident that the floodwater retarding structures have physical limitations on available storage for these purposes. The Southwestern Ohio Water Management Plan will consider sources of water outside of the watershed to help meet these needs.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures:

The Butler and Hamilton Soil and Water Conservation Districts have going programs in the watershed. Land treatment measures applied under these programs are in accordance with land capabilities and good land management. The District's programs will be accelerated to increase watershed protection. The Districts have determined the kind and extent of land treatment measures that land owners in the watershed will install during the period of project installation. The measures are primarily for watershed protection through slower runoff and reduced erosion and sedimentation.

The accelerated program will result in a high percentage of watershed landowners participating in the soil and water conservation program. Landowners will develop basic conservation plans and will have applied a high percentage of the planned soil and water conservation measures.

Land treatment measures are needed to maintain or improve the physical, chemical, and biological condition of the soil. The area treated outside the flood plain will affect runoff, erosion, and sedimentation. Flood plain areas treated will help assure benefits to the structural measures.

Table I shows the acreage by major land use upon which land treatment will be applied. Treatment on the 1,735 acres of cropland may include: Conservation cropping systems contour strip cropping, tillage practices, crop residue management, diversions, grassed waterways drainage mains, drainage field ditches, structures, and tile drains. Grass-

land treatment on 440 acres will include brush and weed control, pasture and hayland management farm ponds and spring development. Treatment on the 30 acres of other land may include ponds, wildlife habitat preservation and development, hedgerow planting, windbreaks, and livestock exclusion.

No formal forest land treatment program has been developed because of the growing urban, industrial and residential development within the watershed. However, the potential for urban forestry should be recognized and consideration given to this aspect of managed use of wooded areas for future public enjoyment. Landowners will be encouraged to install land treatment measures. If interest or installation needs develop technical assistance will be furnished by the Ohio Department of Natural Resources, Division of Forestry and Reclamation in cooperation with the U. S. Forest Service under the going cooperative forestry program.

The Soil Conservation Service will provide technical assistance when needed for installing the land treatment measures.

Fish and Wildlife

Planned land treatment includes wildlife habitat preservation and development, Farm owners will continue to apply measures which provide food, cover, and food for wildlife. Some practices are multipurpose in nature, such as ponds and windbreaks, also attract wildlife. These practices, which are being encouraged on properties throughout the watershed, will help to beautify the area, as well as enhance it for hunting, fishing, and other outdoor recreation.

Structure No. 2 with a permanent multipurpose pool, will be stocked with warm water game fish and made available for public fishing. Structure Nos. 4 and 6, with sizable sediment pools, could also be stocked with fish and used for limited fishing.

Structural Measures:

General - Four single purpose flood prevention reservoirs, one multiple purpose flood prevention-recreation reservoir and 10.4 miles of channel improvement for flood prevention are planned for the project. Basic recreational facilities are planned in connection with the multiple purpose reservoir.

Floodwater Detention Structures - The structures are designed for a useful life of 100 years and will store the expected sediment accumulation for this period. Two structures, Nos. 4 and 6, will have permanent water impoundments equivalent in volume to the estimated sediment accumulation during the first 50 years of structure life, while two structures will have no permanent water impoundments. Structure No. 1 will be dry to facilitate minimum pipeline alterations through the reservoir, and structure No. 5 will be dry because of the large amount of shallow water area in a permanent impoundment. The combined water surface area of the sediment pools is 18 acres.

All reservoir structures (including multiple purpose structure No. 2) will control runoff from storm events expected once in 100 years. When the design storms for floodwater detention are exceeded, emergency spillways will conduct water to stable outlets. Principal spillways will control outflows to provide protection to the flood plains downstream, and will be constructed of reinforced concrete pipe with drop

inlets and impact basin on cantilever outlets (See Figure 4). Emergency spillways will be vegetated.

Principal spillways will in general rest on yielding foundations of unconsolidated materials, with preliminary investigations indicating depth to rock ranging from four to 15 feet in the locations of the principal spillways. Fill materials will be unconsolidated clayey materials (CL, SC and GC), supplemented with shales and limestones from emergency spillway excavations. Proportions and placement of various fill materials will be determined by final investigations, analyses and designs.

The three structures in the East Fork of Mill Creek area will control 7.2 square miles of drainage area, representing 77 percent of the East Fork drainage area. Two structures in the Mill Creek area will control 8.1 square miles, or 27 percent of the drainage area of Mill Creek at its junction with East Fork. Overall control by the one multiple purpose and four floodwater detention structures is 32 percent of total drainage area of Mill Creek at the junction with Sharon Creek.

Multiple Purpose Structures - Structure No. 2 with 3.03 square miles drainage area, is planned for flood prevention and recreation use. The recreation pool of 50 acres surface area and elevation of 658.5 feet will contain 347 acre feet of storage, which is 36.5 percent of the total storage. Floodwater storage capacity is 443 acre feet, and 161 acre feet are allowed for sediment accumulation.

In addition to the water resource improvement, recreational facilities meeting the requirement of state and local health regulations will be constructed. To provide for playground, picnicking, boating and camp-

ing activities, the following basic facilities are planned: a picnic and and playground area with shelter house, playground equipment, parking and toilets; a fishing and boating area with boat rental docks, parking and toilets; a camp ground area with primative camp sites and toilets. Water will be provided to the picnic, playground and camp ground areas. Roads, foot trails and signs will be constructed. In addition to the basic facilities, a headquarters and storage building is planned.

The total recreational park area occupied by the dam and spillway, lake and associated floodwater detention, and recreational facilities is approximately 184 acres. Details of the number and cost of the planned recreational facilities are shown in Table 2B, and a schematic layout of the recreational park is shown in Figure 5.

Channel Improvement - Stream channel improvement of approximately 10.4 miles of channel enlargement will supplement the five floodwater detention structures in providing the desired level of protection. One hundred year outflows from floodwater detention structures and upstream channel improvement were used to design a channel system with the water surface essentially below the average low ground.

Backwater effects from the channel below Sharon Creek are not considered a problem because it is anticipated that channel improvement downstream will be installed according to the official plan of the Mill Creek Valley Conservancy District. The U. S. Army Corps of Engineers is studying the project and plans to complete an interim report in Fiscal Year 1969, containing channel design information for a transition reach to join the two projects. No significant problems are anticipated in making channel improvement designs of the two projects compatible.

The channels will be excavated in materials consisting mainly of silty clay, with scattered layers of sandy clay.

The planned channel improvement affects existing utilities extensively, and the extent of the effects are shown under the heading of Explanation of Installation Costs. Where channel deepening affects existing laterals, the laterals will be excavated to blend into the channel improvement in accordance with sound engineering practice. Allowance has been made for appurtenant structural features to conduct surface and other water into the improved channels. The kind and number of appurtenances will be determined in final design.

The channel improvement on Mill Creek is planned to extend from the aqueduct connecting the old canal and Mill Creek (just above Seward Road) to the junction of Mill Creek and Sharon Run. The material excavated from the channel will be placed to form an effective levee to protect the low lying areas from direct flooding for the approximate stations 269+75 and 366+25, a distance of about 1.8 miles. The spoil is low, averaging about three feet in height and will blend in with spoil placement on the left side of the channel.

East Fork of Mill Creek channel improvement will extend from Allen Road to the junction of East Fork and Mill Creek. A box-inlet drop spillway is planned to convey design flows into the improved channel at Allen Road. Since the design flows are the same in magnitude from Allen Road to the Mill Creek Junction, the drop spillway location could be changed if final design studies show this to be desirable.

Channel improvement design and quantity details are shown in Table 3A and Figure 2 and 3.

EXPLANATION OF INSTALLATION COSTS

Land Treatment Measures:

The costs of installing land treatment measures are summarized in Table 1. The total costs are estimated to be $109,914 of which PL-566 will provide $19,592 to accelerate the application of soil and water conservation practices. The other than PL-566 costs are $90,322 which includes all labor, materials, machinery, and technical assistance under the going program. The direct cost to landowners and operators is $75,186.

Structural Measures:

Explanation of Costs - Construction costs are the engineer's estimated costs plus contingencies. The engineer's estimates were made by applying appropriate unit costs to detailed quantity estimates. Unit costs, based on contract bid schedules and actual construction costs of similar projects in Ohio, were adjusted to the 1968 price level. Cost allowances for contingencies, ranging from 12 to 20 percent of the engineer's estimates, reflect the intensity of site investigations, degree of design detail, and possibilities of encountering latent conditions during construction.

Engineering costs include design surveys, site investigations (borings and laboratory tests), designs, preparation and interpretation of drawings and specifications, and similar services.

Project Administration costs associated with installation of structural measures are those of contract administration, review of engineering plans, government representation for contracts, inspection to assure construction in accordance with drawings and specifications, and overhead.

Overhead includes costs of direct and indirect services of the Soil Conservation Service in installing structural measures under PL-566.

Land rights costs are for land and utilities. Land costs include fee-simple, easement and right-of-way costs, while utility costs include costs of change or removal of existing power, gas and sewer lines, roads and other facilities.

Land costs for floodwater detention and multiple purpose structures are the unit costs (based on fee-simple acquisition) determined by the project sponsors multiplied by the measured areas needed. The areas needed for structure installation are for dams and spillways, permanent pools, floodwater detention, borrow, recreational facilities and construction. Channel improvement land costs are for temporary rights-of-way for construction and permanent rights-of-way for construction, operation and maintenance of the improvement. Different unit rates were used for temporary and permanent rights-of-way costs.

The major utility alterations for which land rights costs are included are listed below.

Works of Improvement	Proposed Alterations to Affected Roads or Utilities
Structures:	
No. 1	Weight two 26" Texas Gas Transmission Corp. pipelines through reservoir.
No. 4	Close Barrett Road through Reservoir. Redesign and relocate Cincinnati Gas & Electric Co. future power line around reservoir (right-of-way for proposed power line is now in conflict with

Works of Improvement	Proposed Alterations to Affected Roads or Utilities
	Structure No. 4). Alter Cincinnati Gas & Electric Company gas line as necessary.
No. 6	Raise West Chester Road over end of dam.
Channels: Mill Creek	(Station designations are approximate) Relocate wooden pole power line where necessary from Sta. 298+00 to Sta. 484+00. Replace State Route 747 bridge (Sta. 368+00). Replace Rialto Road bridge (Sta. 425+45). Lower 16" water line at Sta. 483+05. Protect or relocate as necessary steel power line tower upstream from interstate Route 75 (Sta. 515+00). Replace Windisch Road bridge (Sta. 529+45). Alter Sewer line at Sta. 566+90. Relocate 30" and 36" sewer lines as necessary from Sta. 574+00 to Sta. 712+10. Replace Kemper Road bridge (Sta. 607+70). Relocate water and gas line at Kemper Road (Sta. 607+70). Replace Sharon Road bridge (Sta. 660+95). Relocate as necessary pipeline at Sta. 701+40.
East Fork	Protect water line at Allen Road if necessary (Sta. 329+75). Relocate sewer line if necessary (Sta. 405+60).

Non-Project costs are for installation of five bridges of sizes and useful lives not required for project purposes. Costs of added bridge width (compared with existing width) and greater useful life (compared with remaining useful life of existing bridge) are shown in Table 2 but are not included in the total costs of the project. Costs of longer bridge spans required because of channel improvement are included in land rights costs.

Details of costs for individual structural measures are shown in Table 2.

Allocation of Costs - All costs of channel improvement and floodwater detention structures were allocated to the flood prevention purpose.

Costs for the water resource improvement (dam and lake) portion of miltiple purpose Structure No. 2 were allocated to flood prevention and recreation purposes by the "use of facilities" method. This method provides for equitable sharing of cost savings inherent in a multiple purpose structure by allocating to a purpose in direct proportion to the storage volume available to each purpose. Allocation percentages are 63.5% for flood prevention and 36.5% for recreation. Costs of recreational facilities, including land rights costs for associated floodwater detention, were allocated to the recreation purpose. The summary of allocated costs is shown in Table 2A.

Cost Sharing Construction and engineering services costs for installing the single purpose flood prevention measures will be borne by Public Law 566 funds, while costs of land rights for these measures will be paid by other funds.

For multiple purpose Structure No. 2, the construction costs allocated to flood prevention will be paid from PL-566 funds and costs allocated to recreation, except as noted below, will be shared 50% by PL-566 funds and 50% by Other Funds. Costs of expendable items (refuse cans) and non-basic facilities (headquarters building) will be borne by Other Funds.

The engineering services costs for the Structure No. 2 water resource improvement will be borne by PL-566 funds and costs for the recreational facilities will be shared 50% by PL-566 funds and 50% by Other Funds. Land rights costs, except for surveying and legal fees for land acquisition, will be shared 50% by PL-566 and 50% by Other Funds. Surveying and legal fees will be paid entirely from Other Funds.

The contract administration portion of project administration costs for all structural measures will be borne by other funds and the remaining project administration costs will be paid from PL-566 funds.

Non-project costs of bridge replacement will be borne by the respective agencies responsible for replacement.

Table 2A shows the breakdown of PL-566 and other costs by purpose.

Fund Obligations - The estimated obligation of project funds for land treatment and structural measures for each fiscal year during the installation period is shown below.

FUND OBLIGATIONS

Fiscal Year	PL-566 Funds		Other Funds		Total Fund Obligations
	Land Treatment	Structural Measures	Land Treatment	Structural Measures	
1	$ 2,952	$ 759,500	$13,622	$ 144,670	$ 920,744
2	4,900	1,067,390	22,550	427,430	1,522,270
3	4,900	294,815	22,550	178,425	500,690
4	3,900	1,029,500	18,050	649,775	1,701,225
5	2,940	967,075	13,550	313,630	1,297,195
Total	$19,592	$4,118,280	$90,322	$1,713,930	$5,942,124

EFFECTS OF WORKS OF IMPROVEMENT

Land Treatment Measures:

The effect of the land treatment measures to be installed will be to provide on-site conservation benefits through land improvement, reduced erosion, and greatly improved water management. In addition, the conservation measures will allow the soil to absorb more water and reduce sedimentation. This, in turn, reduces the required design capacity of the channels and the frequency of cleanout and maintenance operations. All landowners in the watershed will benefit from the application of land treatment measures.

It is expected that the land treatment program will not increase the total cropland in the watershed. New urban developments will more than off-set any increases that might be attributed to planned project improvements. In the flood plain area the reduction of frequent flooding of cropland will result in the adoption of improved cropping and management programs. This will result in more economical crop production.

Vegetative cover along the channels will be disturbed during construction. However, there will be grassy cover of equal, or greater, effectiveness provided by seeding of channel banks, berms, and spoil areas. This, along with many land treatment measures, will afford significant benefits to wildlife. The reduction of floods during spring and early summer will reduce the loss of eggs and young of ground nesting species such as song birds, quail, and rabbit.

As the watershed becomes more and more urbanized the land treatment practices will become urban oriented. Many of the urban type land treatment practices are directed towards the benefit of wildlife.

Though the contribution of woodlands towards good hydrologic conditions in this area of rapidly advancing urbanization has been considered unstable, woodlands will not be overlooked when conservation plans are prepared for individual properties. Providing good ground cover in remaining woodlands will be considered well worth while toward reducing runoff and sediment from those area.

Structural Measures - Flood Prevention:

With installation of the project, excess surface runoff from flood producing storms will be trapped in the storage basins provided behind the floodwater retarding structures. The floodwater will be released through conduits at controlled rates that can be handled safely within the downstream channels. The excess surface runoff from the uncontrolled upland will be handled by increased carrying capacity of the channels through the main damage areas. The channels will pass the 100-year design discharges at or below the average low ground. This will eliminate the need for levees and pumps and provide an outlet for good agricultural drainage. With lower discharges below the retarding structures on the main tributaries, the chance of debris obstructing flow at the bridges will be less, relieving some serious local flood situations.

The Upper Mill Creek Watershed Project will provide a 100-year level of protection (1 percent chance of occurrence in any one year) to the main valley and tributaries except for the overflow area below Site No. 2 along State Route 747 and the floodplain between Sites No. 4 and 5 which would be afforded a 25 year level of protection (4 percent chance).

The project will reduce flood stages 5 to 10 feet on the main stem and reduce the 100-year flooded area 89 percent from 3,490 acres to about 390 acres. This remaining area consists largely of old ice ponds and other miscellaneous low areas that are now leveed off. No problems are anticipated in raising building elevations above the 100-year protection level with depts of needed fill only ranging from 0 to 4 feet. The maps, figure 1, show the estimated future 100-year flooded area with and without the project.

With the project installed, a repeat of the Janury, 1959 flood would only cause negligible damage with the flood flows being contained within the main channels. Effects of the project on flood stages are shown graphically on figure 2 for the 100-year and a 2-year future existing floods. The hydraulic grade line on the profile is the design 100-year flood profile with the floodwater retarding structures and channel improvement in place with a free outlet below Sharon Creek.

The total reduction of floodwater damages with the installation of the project will be nearly 100 percent. Damages and benefits for floods greater than 100-year were not evaluated.

Benefits were evaluated on 3,490 acres that are now and will be directly affected by floodwater. There are approximately 65 farms with land in this acreage. The project will also provide a "flood free" condition for the 7.9 miles of highways and 6.5 miles of railroad bed in the watershed on which floodwater damages were evaluated. Present and future urban and industrial development will be the same high level

of flood protection. There are now 15 business and industrial properties within the flooded area.

The reduction of peak flows below the floodwater retarding structures will allow considerable savings on future bridge replacements. These savings, however, are offset by the increased size of bridges required to span the channels which would be enlarged by the project. The following table gives estimated discharges for the 100-year flood under the different conditions at significant locations:

Location	100-Year Discharges			
	Existing	Future Without Project	Future With Project	% Decrease or Increase With Project
Seward Road	1,800	2,250	540	- 76%
S. R. 747 (Lateral)	2,490	2,540	980	- 61%
S. R. 747 (Main)	3,250	5,960	5,220	- 12%
Rialto Road	2,830	5,610	5,920	+ 6%
I.S. 75	2,760	5,100	6,480	+ 27%
Co. Line (Mill Creek)	2,670	5,110	6,940	+ 36%
Allen Rd. (East Fork)	2,370	2,900	1,160	- 60%
Co. Line (East Fork)	1,550	2,350	1,360	- 42%
I.S. 275	4,500	8,290	9,850	+ 19%
Above Sharon Creek	4,750	8,075 1/	12,780 1/	+ 58%

1/ Assumes free outlet for main stem and tributaries in Hamilton County.

The five floodwater retarding structures in Butler County, if installed without channel improvement, will have a significant effect on the reduction of floodwater damages. Together they would reduce all damages 70 percent. The major effect of the structures would be in the reaches immediately below the dams. The stage reduction for the 100-year flood varies from less than 1.0 foot on Mill Creek in Butler County to about 1.5 feet in Hamilton County and over 2.0 feet on East Fork. This stage reduction does enable, however, the crediting of considerable non-agricultural benefits to the structures. The reduction of average annual damages to agriculture, transportation and urban were calculated to be 13, 61, and 71 percent respectively.

Land use changes on the flood plain have been, and will continue to be, from the present agriculture use to urban. Agricultural benefits that might accrue due to changed use or more intensive use of flood plain land would be insignificant, over the life of the project, and were not evaluated.

Incidental recreation benefits were not evaluated at the two single purpose floodwater retarding structures with wet sediment pools. Access to these pools is not expected to be available to the general public or organized groups.

The population of the watershed is estimated at 20,730. Most of the residents work in the industries located in the benefited area. At the last count there were 65 farms and 19 industries subject to flood damage in the benefited area.

An additional 18 industries are located between bypass U. S. 50 and Mill Creek. These industries are protected from direct overflow from Mill Creek by an existing levee. As conditions now exist, this levee would have to be raised to protect this area because continued urban developments upstream will cause higher flood flows in the future. No evaluation was made of the benefits that could accrue to these industries with the planned structural measures in place. Another 12 industries located just below the project area at the confluence with Sharon Creek were also not considered in the benefit evaluation.

PROJECT BENEFITS

Land treatment measures are basic to the project and essential to achieving the maximum benefit from structural measures. Most of these benefits are on-site conservation benefits due to improved use and treatment of the soil resources. There are off-site benefits that will result from reduced sedimentation of the future channels. Land treatment benefits have been evaluated at $6,035 in the watershed as shown by footnote to Table 6.

Average annual monetary benefits of $1,673,420 will result from the installation of the works of improvement outlined in this plan. It is expected that these benefits will result from the reduction of flood damage to agricultural land, transportation facilities, and to the existing and projected urban areas; storage of recreational water; and improved local economic conditions.

Benefits occurring from the reduction of damage to crop and pasture lands are estimated to be $5,926 annually. Benefits attributable to a reduction of other agricultural damages to farm roads, bridges, culverts, fences, levees, and debris removal amount to $3,187. Savings in bridge costs were considered minor and were not evaluated.

Average annual benefits of $1,173 are anticipated from floodwater damage reduction to roads and bridges, and $5,072 from railroads.

Additional benefits are attributable to the reduction of floodwater damage to present and future industrial developments. Benefits due to the reduced damage to these urban developments were estimated at $1,302,118 annually.

Indirect benefits amount to $197,429 or 15 percent of the direct benefits.

Planned works of improvement significantly reduce the risk of flooding on 2,850 acres. Reduced risk on this land is expected to bring about more efficient use and result in higher returns from those areas now being used for agricultural pruposes.

Benefits from the recreational facilities planned at Site No. 2 were evaluated at $25,000 annually. The local conservancy district is planning a limited recreational development at this site.

Due to the rapidly changing land use from agricultural to urban, the possible agricultural enhancement benefits were considered minor and were not evaluated.

Local secondary benefits stemming from the project were considered to equal 10 percent of the direct primary project benefits, or $139,566. Secondary benefits from a national viewpoint were considered not pertinent to the economic evaluation.

The installation of this project would have greatly reduced the floodwater damage caused by the major flood of January, 1959. The basin-wide flood damage for this flood would have been reduced 100 percent if the planned work of improvement had been installed

COMPARISON OF BENEFITS AND COSTS

Benefit and cost comparison for the single unit of evaluation is shown in Table 6. Based on primary structural measure benefits without secondarys of $1,533,854, and the average annual cost shown in Tables 4 and 6, the benefit-cost ratio is 7 to 1. The benefit-cost ratio, computed by combining local secondary benefits of $139,566 with primary benefits is 7.6 to 1.

PROJECT INSTALLATION

Land treatment measures will be applied by landowners and operators in cooperation with their Soil and Water Conservation District. Technical assistance for applying the measures will be provided by the Soil Conservation Service and other cooperating agencies. Educational assistance will be provided by the Cooperative Extension Service.

The Soil Conservation Service will assist the sponsoring organizations in developing engineering drawings and specifications and in preparing contracts for construction, and will provide construction layout and inspection for structural measures for flood prevention and

for the water resource improvement portion of Structure No. 2. For the Structure No. 2 basic recreational facilities, the Soil Conservation Service will agree with the Southern Butler County Conservancy District on a contract for the engineering services with an acceptable organization.

The Southern Butler County Conservancy District will be responsible for administering the construction contracts for works of improvement in this work plan.

The Conservancy District has the power of eminent domain to acquire necessary lands, obtain needed funds, enter into contracts, construct works of improvement, and to operate and maintain the works. In securing land, easements and rights-of-way for construction and maintenance of the structural works of improvement, all authority vested in the Conservancy District by law will be used as needed to complete the project. Prior to initiating construction on any single structural measure, the sponsoring organizations will agree to use all the powers at their command to secure the necessary land, easements and rights-of-way for all measures.

Officials of the Ohio State Department of Highways and the counties involved will coordinate their respective road work with the construction schedule of the Conservancy District.

The time required to install all planned land treatment and Structural measures is estimated at five years.

Since Structure No. 5 is designed with Structure No. 4 in place,

No. 4 must be constructed before No. 5; since the channel improvements are designed with the structures in place, structure construction must precede channel improvement. In order to realize maximum benefits from structural measures and to accomplish construction with a minimum amount of inconvenience, delay and risk, the following installation sequence is recommended:

Installation Year	Structural Measures to be Installed
1	Structure Nos. 4 and 6.
2	Structure No. 1 and the Water Resource Improvement portion of Structure No. 2.
3	Structure No. 2 Recreational Facilities and Structure No. 5.
4	East Fork Channel Improvement and Mill Creek Channel Improvement downstream from the junction with East Fork
5	Mill Creek Channel Improvement upstream from the junction with East Fork.

Table 7 shows construction units of single structures and groups of closely related structural measures which are economically justified in the absence of the remaining works of improvement included in the project.

Channel improvement construction, as outlined in this plan, must not be installed prior to channel improvement work as outlined by the Mill Creek Valley Conservancy District official plan or as modified.

Construction of the channel improvements should be scheduled concurrently with the work of improvements in Hamilton County immediately downstream from the downstream end of this project.

FINANCING PROJECT INSTALLATION

The Butler and Hamilton Soil and Water Conservation Districts will carry out programs to accelerate the installation of land treatment measures contained in this plan. Of the estimated $109,914 cost of installing land treatment measures, the cost to landowners is estimated at $90,322. It is expected that the Agricultural Conservation Program cost-sharing will be available to qualified landowners for installing their measures. The current level of technical assistance will be supplemented by $19,592 of PL-566 funds. Table I shows the amount of land to be treated.

The Southern Butler County Conservancy Districts will be financially responsible for the local share of the costs of installing all structural works of improvement. The Southern Butler County Conservancy District anticipates a financial arrangement with the Butler County Park District for construction of the recreational facilities at Structure No. 2, and for the local share of the cost of the Structure No. 2 water resource development allocated to recreation. Funds for the Conservancy Distric obligations will be obtained by assessments of benefited properties under the authority of the Ohio Revised Code covering Conservancy

Districts, or by other means.

The total project cost of all structural measures to be paid by "Other" funds is estimated to be $1,713,930 as shown in Table 2.

It is expected that the Ohio Department of Highways and the counties involved will bear the non-project bridge replacement costs from their regular funds available for this purpose. These estimated costs total $288,600 as shown in Table 2.

Federal assistance for installing works of improvement will be provided under the authority of the Watershed Portection and Flood Prevention Act (PL-566 - 83rd Congress; 68 Sta. 666) as amended.

When legal requirements have been met, the Soil Conservation Service will make available an estimated $4,118,280 of PL-566 funds for structural measures which includes $455,545 for engineering and $615,310 for project administration. These funds will be furnished as needed and as they become available.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land treatment measures for watershed protection on privately owned land will be installed, operated,and maintained by landowners under cooperative agreements with their Soil and Water Conservation Districts. Technical assistance of the Soil Conservation Service will be provided, upon request, to the land owners and operators to determine needs and to encourage them to perform needed maintenance.

Forest land treatment measures installed on private land will be operated and maintained by the landowners with technical assistance with the U. S. Forest Service under the going Cooperative Forestry Programs.

Structural measures installed will be operated and maintained by the Southern Butler County Conservancy District.

Operation and maintenance agreements between the Soil Conservation Service and the responsible Conservancy District will be executed prior to issuing invitations to bid on construction contracts. The District will assume responsibility for operation and maintenance immediately after acceptance of construction from the contractor. Operation and maintenance work will be accomplished by the responsible organizations using their staffs and materials and equipment, or by contracts or force accounts. Funds needed will be raised by the District through normal legal procedures, or by other means.

Private bridges and facilities of public utilities will be maintained by the respective owners. All other bridge maintenance will be handled by officials responsible for such maintenance from funds appropriated for that purpose.

The estimated total annual operation and maintenance costs shown in Table 4 are $22,110, of which $7,585 is for channel improvement and $2,525 for floodwater detention structures and the water resource improvement portion of Structure No. 2. The estimated operating costs for the recreational development at Structure No. 2 are $12,000. These include $2,300 for maintenance and replacement of recreational facilities, $2,900 for equipment operation, utilities and supplies, and $6,800 for personnel to manage and maintain the development.

Inspections of the individual structures and channels will be made annually, after unusually severe floods, and after the occurrence

of any other unusual conditions that may adversely affect the works of improvement. The inspections will be made by representatives of the sponsoring organizations and the Soil Conservation Service. Authorized persons will have free access for the inspections. Inspections will continue for three years following the installation of each work of improvement, and thereafter, yearly inspections will be made by the sponsors.

Items of inspection will include, but not be limited to, the condition and proper functioning of the concrete work, earth fills, principal and emergency spillways, vegetative growth, channel banks, capacities and appurtenances, bridge abutments, and accumulation of sediment and debris.

Inspection reports indicating maintenance needed will be prepared with a copy furnished to the Soil Conservation Service. The reports, with a record of the action taken, will be kept by the Conservancy District.

Vegetative growth on the works of improvement will be maintained in a vigorous condition by reseeding, fertilizing and other means as necessary. Unwanted vegetation will be controlled by spraying, mowing or other means.

Erosion damage will be repaired promptly and rodents controlled where necessary. Undesirable debris and sediemnt accumulations will be disponsed of.

It is anticipated that the Southern Butler County Conservancy District will enter into a contract with the Butler County Park Dis-

trict for the operation and maintenance of the recreational development of Structure No. 2. The development would then be operated with the equipment and personnel of the Butler County Park system, and in accordance with state and local health regulations. No admission charge is anticipated. Since no conservation water storage other than for recreation is included in Structure No. 2, the permanent water level (except for evaporation and seepage) will remain at elevation 658.5.

TABLE I - ESTIMATED PROJECT INSTALLATION COST

Upper Mill Creek Watershed, Ohio

Sheet 1 of 2

Installation Cost Item	Acres to be Treated 2/	Estimated Cost (Dollars) 1/		Total
		P.L. 566	Other	
LAND TREATMENT				
Soil Conservation Service				
Cropland	1,735		31,580	31,580
Grassland	440		22,940	22,940
Other Land	30		20,666	20,666
Technical Assistance		19,592	15,136	34,728
SCS Subtotal	2,205	19,592	90,322	109,914
Forest Service				
FS Subtotal 3/	-	-	-	-
TOTAL LAND TREATMENT	2,205	19,592	90,322	109,914

1/ Price Base 1968.

2/ Non-Federal Land.

3/ U. S. Forest Service has indicated that no forest land treatment program has been planned for the installation period.

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TABLE I - ESTIMATED PROJECT INSTALLATION COSTS

Upper Mill Creek Watershed, Ohio

Sheet 2 of 2

Installation Cost Item	Unit Number	Estimated Cost (Dollars) 1/		Total
		P.L. 566	Other	
STRUCTURAL MEASURES				
Construction				
Soil Conservation Service				
Floodwater Retarding Structures	No. 4	1,108,130		1,108,130
Multiple Purpose Structure	No. 1	394,860	121,145	516,005
Stream Channel Improvement	Mile 10.4	1,452,435		1, 452,435
Subtotal - Construction		2,955,425	121,145	3,076,570
Engineering Services				
Soil Conservation Service		455,545	5,950	461,495
Subtotal - Engineering		455,545	5,950	461,495
Project Administration				
Soil Conservation Service				
Construction Inspection		307,655		307,655
Engineering Contract Servicing 2/		1,750		1,750
Other		305,905	92,300	398,205
Subtotal - Administration		615,310	92,300	707,610
Other Costs				
Land Rights		92,000	1,494,535	1,586,535
Subtotal - Other		92,000	1,494,535	1,586,535
TOTAL STRUCTURAL MEASURES		4,118,280	1,713,930	5,832,210
TOTAL PROJECT		4,137,872	1,804,252	5,942,124
SUMMARY				
Subtotal S.C.S.		4,137,872	1,804,252	5,942,124
TOTAL PROJECT		4,137,872	1,804,252	5,942,124

1/ Price Base 1968.

2/ Review and Servicing of contract for design of Structure No. 2 Recreational Facilities.

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TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(July 1, 1967)

Upper Mill Creek Watershed, Ohio

Measures	Unit	Applied to Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Brush & Weed Control	Ac.	110	1,540
Conservation Cropping System	Ac.	2,830	4,245
Diversion	Ft.	19,500	13,650
Farm Pond	No.	20	50,000
Fishpond Management	No.	16	240
Grassed Waterway or Outlet	Ac.	24	12,200
Hedgerow Planting	Ft.	6,000	360
Livestock, Exclusion	Ac.	56	225
Pasture & Hayland Management	Ac.	225	9,000
Spring Development	No.	6	4,200
Stream Channel Improvement	Ft.	9,420	7,065
Contour Strip Cropping	Ac.	290	2,900
Structure for Water Control	No.	4	8,000
Drainage Field Ditch	Ft.	7,200	2,880
Terrace, Gradient	Ft.	24,664	9,865
Tile Drain	Ft.	81,431	24,430
Tree Planting	Ac.	32	1,940
Wildlife Habitat Preservation	Ac.	18	72
Wildlife Habitat Development	Ac.	14	490
TOTAL			153,302

1/ Price Base 1968.

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TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Upper Mill Creek Watershed, Ohio

(Dollars) 1/

Item	Installation Cost P.L. 566 Funds				Installation Cost - Other Funds				Total Installation Cost
	Construction	Engineering	Land Rights	Total P.L.566	Construction	Engineering	Land Rights	Total Other	
Floodwater Retarding Structures:									
No. 1	387,180	58,075		445,255			263,500	263,500	708,755
No. 4	375,935	56,390		432,325			87,700	87,700	520,025
No. 5	155,365	23,305		178,670			89,000	89,000	267,670
No. 6	189,650	28,445		218,095			40,000	40,000	258,095
Multiple Purpose Structure									
No. 2	357,050	65,515	59,500	482,065	79,710		59,500	139,210	621,275
Recreational Facilities	37,810	5,950 2/	32,500	76,260	41,435	5,950 2/	35,000 3/	82,385	158,645
Channel Improvement									
Mill Creek	1,280,095	192,010		1,472,105	(288,600) 4/		905,165	905,165	2,377,270
East Fork	172,340	25,855		198,195			14,670	14,670	212,865
Subtotal	2,955,425	455,545	92,000	3,502,970	121,145	5,950	1,494,535	1,621,630	5,114,600
Project Administration				615,310				92,300	707,610
GRAND TOTAL	2,955,425	455,545	92,000	4,118,280	121,145	5,950	1,494,535	1,713,930	5,832,210

1/ Price Base 1968.
2/ Engineering contract costs to be borne $5,950 by P.L. 566 funds and $5,950 by Other Funds.
3/ Includes $2,500 for survey, legal fees and other costs.
4/ Non-project cost for replacing five bridges with wider structures of longer life. Project cost of longer spans is included in Other Funds, Land Rights.

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TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY

Upper Mill Creek Watershed, Ohio

(Dollars) 1/

Item	COST ALLOCATION			COST SHARING					
	PURPOSE			P. L. 566			OTHER		
	Flood Prevention	Recreation	Total	Flood Prevention	Recreation	Total	Flood Prevention	Recreation	Total
Floodwater Retarding Structures No. 1,4,5,6	1,754,545		1,754,545	1,274,345		1,274,345	480,200		480,200
Multiple Purpose Structure No. 2	318,940	460,980	779,920	318,940	239,385	558,325		221,595	221,595
Channel Improvement 10.4 Mi.	2,590,135		2,590,135	1,670,300		1,670,300	919,835		919,835
GRAND TOTAL	4,663,620	460,980	5,124,600	3,263,585	239,385	3,502,970	1,400,035	221,595	1,621,630

1/ Price Base 1968.

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TABLE 2B - RECREATIONAL FACILITIES

ESTIMATED CONSTRUCTION COSTS

Upper Mill Creek Watershed, Ohio

(Dollars) 1/

Item	Number	Estimated Unit Cost	Total Construction Cost
Picnic & Playground Area			
Playground Equipment	5 pcs.	400	2,000
Group Shelter House	1	4,000	4,000
Tables	100	40	4,000
Grills	50	25	1,250
Refuse Cans	100	5	500
Pit Toilets	2	3,000	6,000
Parking	100	70	7,000
Fishing & Boating Area			
Boat Rental Docks	150 Lin. Ft.	50	7,500
Pit Toilets	2	1,500	3,000
Parking	60 cars	70	4,200
Camp Grounds			
Primative Camp Site	50	10	500
Refuse Cans	25	5	125
Pit Toilets	2	3,800	7,600
Headquarters & Storage Bldg.	1	3,000	3,000
Water System	1	10,000	10,000
Roads	1.3 Mi.	10,000	13,000
Two Lane Gravel			
Constructed Foot Trails	0.9 Mi.	300	270
Fence			
Property Line	3.0 Mi.	1,600	4,800
Signs			
Entrance	1	200	200
Directional & Informational	10	30	300
GRAND TOTAL			79,245

1/ Price Base 1968.

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TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES AND WATER SUPPLY RESERVOIRS

Upper Mill Creek Watershed, Ohio

ITEM	UNIT	Structure Number 1	2	4	5	6	TOTAL
Class of Structure		C	C	C	C	C	
Drainage Area	Sq. Mi.	5.10	3.03	2.69	2.64	1.88	15.34
Controlled	Sq. Mi.				2.69		2.69
Curve No. (1-day, AMC II)		80	77	80	80	76	
Tc	Hrs.	1.3	.53	1.4	0.9	0.7	
Elevation Top of Dam	Ft.	645.0	675.0	760.6	627.0	694.0	
Crest Emergency Spillway	Ft.	635.2	665.9	752.8	618.2	684.7	
Crest Low Stage inlet	Ft.	621.2	658.5	732.2	608.8	670.5	
Maximum Height of Dam	Ft.	35	46	57	30	44	
Volume of Fill	Cu. Yd.	197,500	395,800	144,700	109,750	165,200	2,315,250
Total Capacity	Ac. Ft.	1,052	951	407	374	260	3,044
Sed. Submerged 1st 50 yrs.	Ac. Ft.			74		55	129
Sed. Submerged 100 yrs.	Ac. Ft.		149				149
Sediment Aerated	Ac. Ft.	225	12	51	67	39	394
Recreation	Ac. Ft.		347				347
Retarding	Ac. Ft.	827	443	282	307	166	2,025
Surface Area							
Sediment Pool	Acres			9		9	18
Recreation	Acres		50				50
Retarding Pool	Acres	101	72	26	52	20	271
Principal Spillway							
Rainfall Volume (areal, 1 day)	In	5.75	5.75	5.75	5.57	5.75	
Rainfall Volume (areal,10 day)	In.	9.71	9.71	9.71	9.71	9.71	
Runoff Volume (10 day)	In.	5.31	4.77	5.31	5.31	4.60	
Low State Capacity (Max.)	cfs.	96	122	201	248	175	
Operation Frequency, Emer.Spwy.	% Chance	1	1	1	1	1	
Diameter of Conduit	In.	30	30	36	48	36	

TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES AND WATER SUPPLY RESERVOIRS

Upper Mill Creek Watershed, Ohio

ITEM	UNIT	Structure Number 1	2	4	5	6	TOTAL
Emergency Spillway							
Rainfall Vol. (ESH) (areal)	In.	9.84	9.84	9.84	9.84	9.84	
Runoff Volume (ESH)	In.	7.37	6.99	7.37	7.37	6.86	
Type		Veg.	Veg.	Veg.	Veg.	Veg.	
Bottom Width	Ft.	300	250	250	350	175	
Velocity of flow (Ve)	Ft. / Sec.	7.4	7.3	8.4	8.6	8.75	
Grade of exit channel	Percent	1.0	2.8	2.6	2.6	2.5	
Max. water surface elev.	Ft.	638.5	668.4	756.1	621.5	688.1	
Freeboard							
Rainfall Vol. (FH) (areal)	In.	25.9	25.9	25.9	25.9	25.9	
Runoff Volume (FH)	In.	23.12	22.63	23.12	23.12	22.46	
Max. water surface elev.	Ft.	644.9	674.9	760.6	626.8	693.8	
Capacity Equivalents							
Sediment Volume	In.	.83	1.00	.87	.47	.94	
Retarding Volume	In.	3.04	2.74	1.96	2.18	1.67	

TABLE 3A - STRUCTURE DATA

CHANNEL

Upper Mill Creek Watershed, Ohio

Downstr. Sta. of Reach	Drainage Area 1/ Sq.Mi.	Capacity cfs Req'd.	Capacity cfs Design	Water Surface Elev.	Hydraulic Gradient (ft/ft)	Channel Dimensions Bottom (ft)	Channel Dimensions Depth (ft)	Channel Dimensions Sides 2/	"n" Value Aged	"n" Value As Built	Ten-Year Velocities Aged	Ten-Year Velocities As Built	
MILL CREEK CHANNEL													
264+15	5.77			603.5			8.5	Upstream End of Channel Improvement					
293+85	6.10	1,030	1,020	600.5	.0010	12	8.5	2:1	.030	.0225	3.4	4.7	26,000
335+15	8.89	1,380	1,420	596.4	.0010	18	8.5	2:1	.030	.0225	3.7	5.0	52,100
367+75	10.06	2,660	2,790	593.1	.0010	35	9.0	2:1	.0275	.0225	4.9	5.6	66,200
425+85	18.66	5,570	5,760	588.5	.0008	70	9.8	2:1	.025	.020	5.0	6.2	227,200
500+00	22.00	6,200	6,170	582.6	.0008	70	10.2	2:1	.025	.020	5.1	6.7	274,600
529+45	23.00	6,710	6,800	580.2	.0008	70	10.7	2:1	.025	.020	5.2	6.8	125,800
548+70	24.34	6,940	6,980	578.7	.0008	70	10.9	2:1	.025	.020	5.8	6.9	77,500
574+40	24.58	6,940	6,980	576.7	.0008	70	10.9	2:1	.025	.020	5.8	6.9	109.700
588+40	29.69	8,740	8,870	575.6	.0008	90	11.0	2:1	.025	.020	6.0	6.9	65,100
608+70	39.16	10,490	10,550	573.5	.0010	100	11.4	2:1	.025	.020	6.8	7.8	96,000
642+45	44.02	11,590	11,600	570.1	.0010	100	11.4	2:1	.025	.020	7.0	8.0	192,300
712+10	47.80	12,780	12,700	563.2	.0010	100	12.0	2:1	.025	.020	7.2	8.3	370,200
EAST FORK CHANNEL													
329+75	8.20			590.5			10.5	Upstream End of Channel Improvement					
429+15	9.36	1,360	1,430	575.6	.0015	6	10.5	2:1	.030	.0225	4.3	6.1	250,600

1/ Drainage Area does not include areas that contribute flood flow only.

2/ Side Slopes horizontal: vertical.

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TABLE 4 - ANNUAL COST

Upper Mill Creek Watershed, Ohio

(Dollars) 1/

Evaluation Unit	Amortization of Installation Cost 2/	Operation and Maintenance Cost	Total
One Unit Four Floodwater Retarding Structures	59,445	1,825	61,270
One Multiple Purpose Structure	26,425	12,700 3/	39,125
Channel Improvement 10.4 miles	87,755	7,585	95,340
Project Administration	-	-	23,975
GRAND TOTAL	173,625	22,110 3/	219,710

1/ Price Base 1968 for Installation Cost and Adjusted Normalized Prices for Operation and Maintenance Cost.

2/ One hundred years at 3¼ percent interest.

3/ Includes $12,000 for operation and maintenance for the recreational facilities.

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Upper Mill Creek Watershed, Ohio

(Dollars) 1/

	Estimated Average Annual Damage		Damage Reduction Benefit 2/
	Without Project	With Project 3/	
Floodwater			
Crop and Pasture	5,926	-	5,926
Other Agricultural	3,187	16	3,187
Non-agricultural			
Transportation	6,245	-	6,245
Urban	1,302,322	204	1,302,118
Subtotal	1,317,680	220	1,317,460
Indirect	197,478	49	197,429
TOTAL	1,515,158	269	1,514,889

1/ Price Base - Adjusted Normalized Prices.

2/ Includes Flood Damage Reduction Benefits of $6,035 for Land Treatment Measures.

3/ Damages and benefits will accrue from floods of greater magnitude than 100-year frequency, but were not evaluated.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Upper Mill Creek Watershed, Ohio

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/				3/ Average Annual Cost	Benefit Cost Ratio
	Damage Reduction	Recreation	Secondary	Total		
Unit 1	1,508,854	25,000	139,566	1,673,420	195,735	
Project Administration					23,975	
GRAND TOTAL	1,508,854	25,000	139,566	1,673,420	219,710	7.6:1.0

1/ Price Base - Adjusted Normalized Prices.

2/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $6,035 annually.

3/ From Table 4.

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TABLE 7 - CONSTRUCTION UNITS

Upper Mill Creek Watershed, Ohio

(Dollars) 1/

Measures in Construction Unit	Annual Benefit	Annual Cost
Mill Creek	1,102,345	151,075
Structure Nos. 1 & 2 Mill Creek Channel Improvement		
East Fork	357,854	44,660
Structure Nos. 4,5, & 6 East Fork Channel Improvement		
Structure No. 1	214,811	24,610
Structure No. 2	551,052	39,125
Structure No. 4	130,783	18,095
Structure Nos. 4 & 5	265,577	27,515
Structure No. 6	137,230	9,145

1/ Adjusted normalized prices for benefits and operation and maintenance costs; price base 1968 for installation costs.

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INVESTIGATION AND ANALYSIS

The Soil Conservation Service, in assisting the sponsoring local organizations, employed the following data, sources, methods, and procedures in the preparation of this plan.

Standard methods and information, contained in prepared handbooks, are referred to by name rather than described here.

LAND USE AND TREATMENT:

Land use and treatment programs proposed in this watershed were planned by the Boards of Supervisors of the Jackson, Lawrence, and Scioto Soil and Water Conservation Districts. Technical assistance was provided by the U.S. Soil Conservation Service, U. S. Forest Service, and the Ohio Division of Forestry and Reclamation.

The Conservation Needs Inventory and basic farm conservation plans within the watershed were used to arrive at the present land use and total conservation needs as outlined in AN-W 748 and supplements. The U. S. Forest Service and the Ohio Division of Forestry and Reclamation made a detailed study of the woodland aspects to determine the woodland needs and amounts of forestry practices to be applied.

The above data were used by the Boards of Supervisors in determining land treatment needs to be met during the project period.

HYDROLOGIC AND HYDRAULIC INVESTIGATIONS:

The following physical data and procedures were used in the design of the proposed structural measures and to determine their effect in reducing floodwater damages. The procedures used, if not referenced, are described in the Soil Conservation Service National Engineering Handbook, Section 4, Hydrology.

Hydrologic Studies - SCS - U. S. Weather Bureau Technical Papers No. 40 and 49 were used to develop rainfall-frequency curves for the watershed. The 24-hour, standard Soil Conservation Service type one, storm distribution was used for the floodwater damage evaluation studies.

Runoff volumes were determined from hydrologic curve numbers calculated for the watershed. These soil-cover complex numbers were based on land use and condition estimates provided by the Soil Conservation Service Work Unit Conservationists. They also provided soils information for the hydrologic soils grouping. The U. S. Forest Service furnished the hydrologic curve numbers for the forest lands.

Runoff-frequency curves were prepared from the rainfall-frequency curves using curve numbers that reflected present and future watershed runoff conditions. The present condition was used in the agricultural damage evaluation with a growing season-frequency developed for floodwater damage to crops and pasture. The future condition was used in the urban and transportation damage evaluation.

The runoff-frequency curves were correlated with discharge-frequency studies of the Mill Creek Stream Gage at Reading, Ohio and other similar gaged watersheds. These studies were used in determining the slope of the runoff-frequency curves, the relation between the annual and growing season peaks, and to compare with routed evaluation and design storms.

The Mill Creek Stream Gage, located three miles further downstream from the watershed, has 28 years of record from a 69.8 square mile area.

The discharge-runoff relationships for the watershed were obtained by a detailed flood routing method. The computer program, TR-20 Project Formulation Program-Hydrology, was utilized for the routings. This program is based upon the convex method for stream flood routing and the storage indication method for reservoir routing.

The following six types of stream flood routings were performed during the work plan development:

1. Present conditions with existing levees.
2. Present conditions modified by project land treatment and floodwater retarding structures installed as planned.
3. Future conditions without a planned flood prevention program, with individual levees and land fill projected onto the undeveloped floodplain.
4. Future with project modified conditions including land treamment, and three combinations of six floodwater retarding structures.
5. Future with project modified conditions including land treatment, four combinations of six floodwater retarding structures and major channel improvement.

6. Future with project modified conditions including land treatment and major channel improvement with no flood water retarding structures.

The 2, 10 and 100-year annual evaluation storms, as well as the January, 1959, historical storm, were routed through the watershed to the Reading Stream Gage for nearly all of the six types of watershed conditions. The 1959 flood was used as a basis for checking and adjusting the hydraulic factors in the present condition routings.

The resultant discharges were related directly to frequency by curves plotted from the computer output for each evaluation reach. Hydrologic reaches were used in routing through the watershed. These were combined into sixteen reaches for the floodwater evaluation.

Hydrologic Studies - Forest Service - Information on the hydrologic condition of the forest land in the watershed and the reasons for the present hydrologic condition were obtained in a series of systematically selected field plots. This information served as the basis for developing precipitation-runoff curve numbers and land treatment needs for the forest land. The data obtained included measurements of the litter and humus layers, determination of soil type and other hydrologic factors. It also included recording the presence or absence of disturbance factors such as fire, grazing, cutting, logging, and the abnormal infestation of insects or diseases which might adversely affect the hydrologic condition or increase the fire hazard. Forest fire protection is provided by the local township fire departments. This protection is considered adequate. Industrial and residential development is expected to substantially reduce the area of forest land within the watershed.

Hydraulic Studies - Engineering field surveys for valley and channel hydraulic studies were tied to mean sea level vertical control datum. The surveys consisted of 20 valley sections, 69 additional channel sections, numerous highwater marks, building elevations and information on 49 roads and bridges. Additional engineering data were obtained from: 7½ min., U. S. Geological Survey, 1955, topographic maps with 10 foot contour intervals; aerial mosaics of the valley and channel and from the official plan of the MillCreek Valley Conservancy District. Other information made available were road and bridge plans including the interstate roads, 5 foot contour maps of the Hamilton County area, 2 foot contour maps of the city of Hamilton Industrial Park and the 1959 flood profile prepared by the Corp. of Engineers.

Major drainage area plainmetered values agree with those of the U. S. Geological Survey except they do not include the flood overflow area from the old canal on the west watershed divide.

Discharge rating curves were developed at the surveyed valley sections for the present condition by water surface profiles. The computer program for Project Formulation Hydraulics-Flood Plains and constrictions was used to determine the water surface profiles with effective levees for given discharges. The results were compared with the 1959 flood discharges, highwater marks and levee elevations.

Discharge rating curves for the future routing condition were developed by projecting the effect of the present development in the lower reaches into the upper areas.

In the modified condition, due to planned channel improvements, the discharge rating curves were revised by Manning's Formula to reflect the improved channel capacity.

Elevation-acres flooded curves were prepared for each economic evaluation reach using overbank top widths and representative reach lengths of the valley cross sections. Reaches were adjusted to correlate the computed flooded area with the 100 and 2 year flood plain outlined on U.S.G.S. topographic maps.

Frequency-acres flooded data were tabulated for each reach from the elevation-stage discharge and runoff-frequency-discharge relationships. The resultant area and depths inundated were determined using a selected array of growing season frequency storms for both natural and modified present conditions in the crop and pasture damage evaluation. Similar data for present and future annual frequency storms were developed to use in the stage - damage relation for determining average annual damages for other agricultural, urban and transportation evaluations.

Floodwater Detention Structure Design Hydrologic Criteria:

The principal spillway design was based on 100-year 24-hour and 10-day design storm rainfall amounts obtained for this watershed from U. S. Weather Bureau's Technical Papers No. 40 and 49.

Individual runoff curve numbers were ceveloped for the structure s sites by a detailed evaluation of their hydrologic soil cover conditions. Future land use changes were used in the development of the curve numbers to determine the runoff from the design storm rainfall. These curve numbers are suitable for final structure design.

Design storm rainfall criteria for the emergency spillway and freeboard hydrographs were obtained from figures 21.5-.9.1/ These criteria are based upon 6-hour, 100-year frequency and 6-hour, maximum probable precipitation maps from U. S. Weather Bureau Technical Paper No. 40.

Design hydrographs used in the detailed flood routing of the structure sites were based on the Soil Conservation Service Central Technical Unit method. The routings were accomplished by the Project Formulation Computer Program for Structure Site Analysis.

Channel Design Hydrologic Criteria:

Runoff-frequency procedures developed in the floodwater damage evaluation were used to determine the discharge-frequency for design of the channel improvements. The design discharges were estimated by flood routing the 100-year future modified with project condition storm through trial channel designs without overbank flow. Final channel design discharges were determined for alternate cost studies with four combinations of structures and no structures at all. All alternates considered a constructed outlet below Sharon Creek similar to the Mill-Creek Valley Conservancy District Official Plan Design.

GEOLOGIC INVESTIGATIONS

Erosion Investigations:

Erosion investigations were made by visual inspection of the Watershed, with a topographic map and aerial photos as a guide. Consultation

1/ Section 4, Hydrology, National Engineering Handbook, SCS.

with the local work unit conservationist was also made.

Inspection did not reveal major areas of active erosion. Although sheet erosion is occuring throughout the watershed it is felt to be minor. Much of the uncultivated land is in pasture or small brush. Gullying is minor, and occurs mainly in the head regions of streams as normal head cutting.

Sediment storage requirements for all proposed dam sites were computed in accordance with SCS Engineering Memo No. 27 (Rev.), Supplement I and Technical Release No. 12. Land Use Data obtained from the work unit conservationist was used for sheet erosion. Streambank erosion was determined from aerial photo studies. In addition to these two types of erosion, accelerated sheet erosion will come from building construction. Each particular construction site is expected to yield sediment for a short time. Sediment records from Lake Barcroft, Virginia, an area surrounded by suburban construction, and Sharon Woods Reservoir in Hamilton County were studied for comparison. An additional factor of 11 tons of sediment per acre per year was added to the sediment eroded from other sources, for the proposed structures. Total acres for construction was estimated from future land use data.

Flood plain scour was not noticed during the course of investigation.

Sediment Investigations:

Infertile overwash was not found to be a problem. Visual inspection and hand borings did not reveal measurable sediment, and no further studies were considered necessary.

Structure Site Investigations:

Five structure sites were investigated by means of visual inspection, hand boring and probe. Use of a refraction type seismograph was not possible because of strong background vibration that interfered with instrument use.

Two geologic maps of the entire watershed were prepared showing bedrock and glacial geology. Topograph maps of each site were also used, and cross sections of structure centerlines were prepared. Hand borings and depths to rock were plotted on them.

All structure sites, except No. 5 which is in the Eden Formation, lie within the Maysville. Outcrops of both formations were examined to determine ease of rock removal in conjunction with dam construction. Both formations are horizontally bedded calcareous shales with thin bedded limestones and should present no problems. No faulting, fracturing, major jointing, or caverns were found.

Overlying the bedrock in the uplands is glacial till of varying thickness. The average depth in the uplands is 5 feet, although thicker areas such as drumlins and terminal moraines are found in the watershed. The soils comprising the till are mainly CL soils, silty clays with scattered sandy areas and gravel layers.

All sites, except No. 4, lie across tributaries to the pre-glacial Norwood stream. Depths to rock in the valley bottoms for these sites is adequate, and construction is not expected to encounter rock below the foundations. Excavation of the emergency spillways in site Nos. 1 and 2 will be in rock, but in till in site No. 6, and in a drumlin

in site No. 5. Leakage problems are not anticipated. Borrow is of adequate quantity and quality. Gravels, found at sites No. 5 and 6 do not appear to extend to the fill centerline locations.

Site No. 4 will present greater problems in construction. Bedrock here, is at shallow depths, both in the foundation, abutments and emergency spillway area. Borrow, although of good quality, is scarce, and rock materials may have to be used in the fill. Investigation of the abandoned railroad fill downstream from this site could not reveal its composition, and its use for borrow is not contemplated.

Channel Investigations:

Mill Creek flows through the valley of Norwood Stream, a pre-glacial tributary of the old Teays River. Valley fill beneath Mill Creek averages 200 feet thick clays and sands.

Channel stability investigations were carried out on Mill Creek from Seward Road to the junction with Sharon Creek; and on East Fork of Mill Creek from Allen Road to its junction with Mill Creek. Visual observation, combined with hand auger, were used to determine soil type within the channel. The banks consist mainly of silty clays, CL, with scattered layers of sandy clay. In view of non-cohesive materials, it is expected that channel stability can be maintained at 2:1 side slopes. The project involves widening the channels with minor deepening. Bedrock was not encountered below the stream channel.

Future Investigations:

Detailed geological investigations will be made during the operations stage. Investigation will be carried out by power drill at all

sites and stream channels. Samples for detailed analysis will be collected and sent to the soil mechanics lab for testing. Detailed geologic reports, together with lab analysis,will be furnished design and project engineers. Estimates for detailed site investigations are included in costs presented in the plan.

Structural Measures Design:

General - Hydrologic and hydraulic designs of structural measures have been made in sufficient detail to be used in the installation phase of the project. It is intended that design information presented in the plan be used in final design as a basis for preparation of construction drawings and specifications, unless latent conditions or other major changes dictate revisions. Table 3 shows design elevations and emergency spillway bottom widths suitable for final design, for floodwater detention and multiple structures; Table 3A and Figure 2 show channel improvement elevations, bottom widths and side slope data suitable for final design.

Floodwater Detention Structures - Designs are based upon criteria established in Soil Conservation Service Engineering Memorandum 27. Various design references, such as S.C.S. National Engineering Handbook Section 4, Chapter 21 and Section 5, were used.

All structures were designed to store the expected 100-year sediment accumulation, with permanent pools at the 50-year sediment elevation planned for Structure Nos. 4 and 6.

Principal spillways were sized and proportioned after considering the following factors:

1. Downstream channel capacities and the flood reductions due to the reductions in discharge rates. Hydrologic studies were referred to in selecting principal spillway sizes.
2. Drawdown time limitations and the damages that may result from prolonged storage and outflows.
3. Economics of various spillway sizes in passing base flows and design storm hydrographs.

Emergency spillway crest elevations were established by reservoir flood routings of the 100-year, 10-day duration storm with average antece dent moisture conditions (AMCII). All principal spillways were designed with single stage inlets, and will essentially discharge the floodwater detention storage in ten days or less. Detention volumes range from 1.67 to 3.04 watershed inches as shown in Table 3.

Elevation-area and elevation-storage volume information was obtained from topographic maps (scale 1" = 200' and contour interval four feet) by planimetering the areas bounded by the contour lines and the dam centerlines. The areas and volumes occupied by the upstream portion of the fills were deducted from the gross area and volume curves.

Final design flood routings, except for the principal spillway storm routing for Structure No. 5, were performed by electronic digital computer. Results were checked against preliminary hand calculations. Resulting floodwater detention volumes were checked against minimum Soil Conservation Service standards for Ohio. Storm hydrographs for Structure No. 5, the downstream structure in series with Structure No. 4,

were developed using the outflows from Structure No. 4 and the storm runoff rates from the uncontrolled drainage area between the two structures. To facilitate designs using the DAMS computer program, the Structure No. 5 principal spillway storm was routed by hand, using the storage indication method of flood routing.

Emergency spillways were proportioned by studying costs of excavation, fill and land rights. Cost analyses for various emergency spillway widths were made. Standard inlet profiles with control sections were used for all emergency spillways except No. 1. Discharge capacity rating curves for these spillways were obtained from Technical Release No. 35, while the curve for Structure No. 1 was obtained by computing water surface profiles upstream from the emergency spillway outlet. Maximum allowable velocities during passage of the emergency spillway hydrograph were not exceeded.

For Structure Nos. 1, 2 and 4, where emergency excavation is expected to end in rock, excavation below the design emergency spillway grade line is planned to protect the rock from weathering. Backfill will be with earth materials to the design grade line. All emergency spillways are classed as "vegetated."

Preliminary analyses of available fill materials and their use potential were made. From available geologic data on fill materials, it appears most economical to include some rock from emergency spillway excavation in the embankment of Structure No. 4. Final design studies may indicate that rock can be economically used on Structure Nos. 1 and 2. Borrow areas for inconsolidated fill material outside the

emergency spillway and reservoir area are anticipated for Structure Nos. 4 and 6, and appropriate cost estimates have been included.

Multiple Purpose (Recreation) Structure - Design investigations and analyses for the dam and spillway portion of Structure No. 2 are described in the preceding section. The Soil Conservation Service and the Southern Butler County Conservancy District have tentatively agreed on the type and quality of basic recreational facilities to be installed at Structure No. 2. Final designs for recreational facilities will be in accordance with the standards of the organization responsible for the engineering services for the facilities. The organization providing engineering services will be mutually acceptable to the Soil Conservation Service and the Southern Butler County Conservancy District.

Channel Improvement - Soil Conservation Service "Standards and Specifications for Open Ditches" in Ohio, National Engineering Handbook, Section 16 (Drainage) Technical Release No. 25, "Planning and Design of Open Channels" and appropriate engineering memoranda were used as criteria and guides for the design of channel works of improvement. Engineering field surveys made by S.C.S. personnel and data from U. S. Geological Survey quadrangle maps and aerial photographic mosaic maps (1" = 200' scale) were used. Channel profiles for design and cross-sections for quantity estimates were developed from this information.

Required capacities were determined by flood routings described under Hydrologic and Hydraulic Investigations. Designs were based on the Manning equation after determining that steady and uniform flow conditions existed. Channel capacities were based on the peak 100-year

flows. Hydraulic roughness ("n") values to be expected after vegetation has been established and maintained ("aged" channel condition) were used for channel capacity design, and velocities were checked for "n" values for both the "aged" and newly constructed ("as built") channel conditions.

On East Fork of Mill Creek, a drop spillway is planned to reduce the ten-year velocities to an acceptable level. For East Fork design, the most severe condition to be expected, that of no backwater from the Mill Creek Channel, was used for velocity determinations.

Allowable velocities were determined considering channel size, bank and bed materials, and experiences with other open ditches with similar grades in the area. Where the higher allowable velocities were used, appropriately higher cost estimates for operation and maintenance were made. For channels with bottom widths of 50 feet and greater, V-shaped excavation below the design channel bottom (4% slope from toe of side slope to channel centerline) is planned to concentrate low flows in the center of the channel (See Figure 3).

Channel design quantities are summarized in Table 3A, and related information is shown in Figures 2 and 3.

ECONOMIC INVESTIGATIONS

General:

Damages and benefits were calculated from basic economic information obtained from various reports and field investigations. Interviews with flood plain operators and local agricultural technicians were made to determine the type, extent, and location of agricultural damages. Other

damage data were obtained from local people and officials.

Damages and benefits were computed by using interim price standards established by the Interdepartmental Staff Committee of the Water Resources Council.

Costs of planned works of improvement are based on current construction costs for southwestern Ohio. Estimated land, easements, and rights-of-way values were based on recent local transactions. For lands having 100 percent loss of present use, costs were computed for fee simple title acquisition. Costs of lands used for temporary pool areas and channel construction were based on easement values. The estimated economic life of the structural measures is 100 years. Annual installation costs were computed by the application of an interest rate of 3 $\frac{1}{4}$ percent for amortization based on the economic life of the improvements.

Agricultural Floodwater and Sediment Damage:

Floodwater and sediment damage to crops and pasture constitute the majority of the damages computed as agricultural. Farmer interviews with approximately 10 percent of the flood plain operators, plus consultation with local agricultural technicians and correlation with recent crop damage history, provided a basis to establish a damageable value per acre for the principal crops in the flood plain area. Loss of expected yields, lost production costs, and extra tillage operations were taken into account in establishing these damageable values. The season of expected flood occurrence, and the depth and duration of flooding waters were correlated and weighed into the over-all damage estimate to obtain a composite-acre damage and stage-damage value for

each reach.

Hydrologic data provided area flooded-frequency of occurrence relationships. With this information and composite-acre-damage data, existing average annual damages by reaches were determined for the inundated areas.

Utilizing the flood damage-frequency of occurrence relationship for "without" and "with" project installations, it was possible to determine the average annual flood damages prevented. These reductions are considered as benefits to the project and are summarized in Table 5.

Other agricultural floodwater damages involving farm flood gates, fences, farm buildings, rural homes, farm lanes, culverts, livestock loss, and debris pickup were obtained by interviews and related data from similar watersheds. Average annual damages "without" and "with" project were computed by use of the stage-damage-frequency relationships.

Due to the rapidly changing land use, from agriculture to urban, all agricultural damages and the damage reduction benefits resulting from project measures were considered as decreasing annuities.

Other Flood Prevention Benefits to Agriculture:

Agricultural changed land use and more intensive use benefits that might accrue during the change from agriculture to urban use were considered to be minor and were not evaluated.

Transportation Facilities Damages:

Public road, railroad and bridge floodwater damage data were obtained from local residents, and responsible state, county, and township road officials. Where detailed information was lacking, applicable data from

another similar watershed were projected.

These data were used to develop stage-damage-frequency relationships per mile of inundated road for use in computing existing annual damages and remaining damages "with" project. Damages prevented constitute the public road transportation benefits. All reaches were separately evaluated for floodwater damage to roads.

Urban Floodwater and Sediment Damages:

Urban floodwater damages and the damage reduction benefits resulting from project measures shown in this plan include projections. Dollar values used in the projection are based on estimated damages that have, or could, occur to existing urban developments now on the flood plain. A study covering the period 1938 to the present shows that the urban development of the flood plain will completely cover the presently undeveloped areas in the next 20 to 25 years. Appropriate lag factors were used in evaluating the damages in the areas that will be developed in the future.

Zoning regulations which presently cover most of the undeveloped flood plain in Butler County that is now being used for agricultural purposes, dictates that its future use will be for industrial development. A small area in and near the town of Westchester is zoned residential and was appropriately evaluated.

In the Port Union-Rialto section of the flood plain there are limited areas below the 100-year frequency elevations. Similar low areas in the present industrial developments downstream have been filled, at little or no cost, with surplus excavated material resulting

from new construction. Therefore, it was not necessary to make a separate evaluation of these areas.

Indirect Damages

All indirect damages were estimated as a percentage of the direct floodwater and sediment damages. The indirect damages to the urban areas were estimated to be 15 percent of the direct damages.

Ten percent was used for such agricultural losses. These losses include the inability to market farm products in a timely manner, losses of productive use of farm labor and machinery, etc.

Indirect damages resulting from direct damages to public roads, railroads, bridges and culverts were estimated at 20 percent. Excessive travel costs are incurred from rerouting traffic around flooded and washed out roads. Traffic rerouted over secondary roads, not built to withstand heavy traffic, results in high road maintenance costs in an area having limited revenues for this purpose. Extra travel and expense is also incurred due to the closing of normal bus routes for transporting school children. During flooding many people in the watershed are faced with extra travel and expense to obtain needed goods and services, and to get to and from their places of employment.

Recreation Benefits

Structure No. 2 is a multiple purpose flood prevention-recreation reservoir. A limited public recreation facility will be developed adjacent to this reservoir. A statewide inventory, showing visitor-day use of similar recreation areas, was used as the basis for estimating the use of this facility. The visitor-day rate of $1.00 was used in the evaluation.

The possible incidental recreation use of the conservation pools at Structure Nos. 1, 4 and 6 was not evaluated because public access was not assured.

Secondary Benefits:

Local secondary benefits stemming from the project were evaluated at 10 percent of the direct primary project benefits.

Secondary benefits occurring outside the project area were not evaluated.